Lipid content describing the behavior of coral larvae in high pCO2 within shallow tropical reefs in Okinawa, Japan from 2016-07 to 2016-08

Website: https://www.bco-dmo.org/dataset/751028
Data Type: Other Field Results
Version: 1
Version Date: 2018-12-07

Project
» Collaborative Research: Ocean Acidification and Coral Reefs: Scale Dependence and Adaptive Capacity (OA coral adaptation)

Program
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Contributors	Affiliation	Role
Bergman, Jessica	California State University Northridge (CSUN)	Principal Investigator
Edmunds, Peter J.	California State University Northridge (CSUN)	Co-Principal Investigator
Biddle, Mathew	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Twelve colonies of Pocillopora damicornis (Linnaeus 1758) were collected in July and August 2016 from ~ 1-m depth on a patch reef on the northwest shore of Okinawa (26°40’18.24” N, 127°53’4.78” E). Colonies were collected prior to expected larval release in Okinawa in July and August (S. Harii, unpublished data on the study site), with peak release occurring ~ 7 days after the new moon. Following collection, colonies were transferred to Sesoko Station, part of the Tropical Biosphere Research Center University of the Ryukyus, where they were incubated outdoors in individual containers exposed to natural irradiance in flow-through seawater. Ambient seawater was pumped at 3.0 L min-1 (AC Flowmeter, Tokyo Keiso Co., Japan) from 4–5 m depth and stored in two 10 L reservoirs. Air was bubbled constantly in to the reservoirs at 3.0 L min-1 to maintain ambient seawater pCO2 (i.e., the control conditions). Seawater temperature was measured hourly at 1–2-m depth near the collection site prior to, and during, the experiment (HOBO Pro v2, Onset Computer Corporation, USA), and was 29.9 ± 0.2°C (mean ± SE, n = 45 days), with a daily minimum of 28.3°C and daily maximum of 31.8°C (R. Prasetia & S. Harii, unpublished data) that reflects summertime diurnal warming in this location. Temperature in the containers holding the corals was maintained within this range during the experiment (29.8 ± < 0.2°C, mean ± SE, n = 31) using a chiller (ZR-130E, Zensui, Japan). Planulae released from P. damicornis during the first quarter moon of July and August were collected at ~ 05:00 hrs following their release at ~ 03:00 hrs, using containers lined with 110 µm plankton mesh. As larvae from P. damicornis are physiologically dissimilar among days of release, larvae were collected from the inferred day of peak release and pooled among colonies releasing larvae on this day. Larvae from July and August were used to test the effects of pCO2 (two levels) and depths (two levels) on larval behavior, and the experiment was conducted in two parts. The first part (July 2016) tested the effects of two pCO2 regimes on larval behavior with the tubes positioned with their upper opening adjacent to the air-water interface of the seawater (hereafter “shallow” tubes), and the second part (August 2016) tested the effects of the same two pCO2 regimes on larval behavior with the tubes positioned with their upper opening ~3–4 m below the surface (hereafter “deep” tubes).

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Coverage

Spatial Extent: **Lat**:26.6717 **Lon**:127.8847
Temporal Extent: 2016-07 - 2016-08

Dataset Description

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Methods & Sampling

Lipid content
To test for changes in total lipid content in the larvae following incubations under ambient and high pCO2, the initial lipid content of larvae was determined in three samples of 50 larvae, freshly released from the maternal colonies at 06:00 hrs and pooled among them. Each batch of larvae was placed in 1.5-mL vials for processing. The final lipid content of the larvae (i.e., 24 h after the start of incubations) was determined by processing batches of larvae in the same way following 24 h in ambient or high pCO2 in either shallow (July) or deep (August) locations. Tubes incubated on the reef were returned to the lab 24 h after the start of each experiment (i.e., 08:00 hrs the following day), and all living larvae were collected by rinsing the contents of each tube into a collection container. Retrieved larvae were counted, and a single batch of 50 larvae from each tube at both depths was placed in a 1.5 mL vial for measurement of lipid content.

After transferring the batches of larvae to 1.5-mL vials, excess seawater was removed from the vials using a Pasteur pipette, and the larvae were frozen at -80°C for lipid analysis within 2–4 weeks. Following the protocol of Harii et al. (2010) with slight modifications, lipids were extracted with 5 mL dichloromethane-methanol (6:4) in an ultrasonic bath at room temperature for 15 minutes. Each batch of 50 larvae was extracted three times, with the solvent and eluted lipid pooled among extracts. Extracted lipids were concentrated in a rotary evaporator for 15–20 min. Following complete evaporation, the residue was dissolved in dichloromethane 6 times, and centrifuged to separate lipids from water. The solvent containing dissolved lipids was transferred to a new 50 mL flask after each separation. After washing 6 times, the samples were partially evaporated once

again for ~ 5 min, and passed through a ~ 1 cm column of Na2SO4 crystals and plastic wool to remove water. Samples drained by gravity from the column into 4-mL pre-combusted glass vials (400°C for 4 hrs), in which they were then dried under nitrogen gas and weighed using a microbalance (± 1 µg, MT5, Mettler-Toledo, USA). Larval lipid content was expressed as µg larva-1.

Statistical analysis
Statistical analyses were conducted using SYSTAT Version 11 software (Systat Software, San Jose, CA). A two-factor RM ANOVA was used to compare the effects of depth and pCO2 on larval position in the tubes, with time of day as the RM factor and arcsine-transformed values of the percentage of larvae found in the top of each tube as the dependent variable. Differences in lipid content of larvae were evaluated using a two-sample t-test to compare the effect of pCO2 on total lipid between depths, and a Kruskal-Wallis non-parametric test (due to violations of normality in the data) to compare lipid content after pCO2 incubations regardless of month. Assumptions of normality and homogeneity of variance for the RM-ANOVA were assessed through graphical analyses of the residuals.

Data Processing Description

BCO-DMO Processing Notes:

- translated Excel spreadsheet to a comma separated file
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions

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Data Files

File
lipid.csv (Comma Separated Values (.csv), 704 bytes) MD5:8aa1ed7985051297ad282624d97f076b Primary data file for dataset ID 751028

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Related Publications

Bergman, J. L., Harii, S., Kurihara, H., & Edmunds, P. J. (2018). Behavior of Brooded Coral Larvae in Response to Elevated pCO2. Frontiers in Marine Science, 5. doi:10.3389/fmars.2018.00051
Results

Harii, S., Yamamoto, M., & Hoegh-Guldberg, O. (2010). The relative contribution of dinoflagellate photosynthesis and stored lipids to the survivorship of symbiotic larvae of the reef-building corals. Marine Biology, 157(6), 1215–1224. doi:10.1007/s00227-010-1401-0
Methods

Mehrbach, C., Culberson, C. H., Hawley, J. E., & Pytkowicx, R. M. (1973). Measurement of the apparent dissociation constants of carbonic acid in seawater at atmospheric pressure. Limnology and Oceanography, 18(6), 897–907. doi:10.4319/lo.1973.18.6.0897
Methods

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Parameters

Parameter	Description	Units
Depth	depth at which larvae were incubated	meters (m)
Trial	i = initial ambient larvae; f = final ambient larvae; t = final treatment larvae. Ambient conditions are 400 uatm pCO2; treatment conditions are 1000 uatm pCO2.	unitless
Initial_weight	weight of empty bottle used	miligrams (mg)
Final_weight	weight of bottle + extracted lipids	miligrams (mg)
Difference	Difference between initial weight of bottle and weight of bottle + lipids (weight of lipids)	miligrams (mg)
Lipid_per_larvae	Weight of lipids divided by # of larvae used for extraction	unitless

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Instruments

Dataset-specific Instrument Name	handheld meter
Generic Instrument Name	Multi Parameter Portable Meter
Dataset-specific Description	Seawater pH and temperature in the reservoir were measured daily between 09:00 hrs and 11:00 hrs using a handheld meter (Multi 3410, WTW, Germany) fitted with a combination probe that recorded pH (± 0.001 pH unit) and temperature (± 0.1°C) (SenTix 940, WTW, Germany).
Generic Instrument Description	An analytical instrument that can measure multiple parameters, such as pH, EC, TDS, DO and temperature with one device and is portable or hand-held.

Dataset-specific Instrument Name	autoburette titrator
Generic Instrument Name	Titrator
Dataset-specific Description	The salinity of the seawater used to fill the larval incubation tubes was measured using a conductivity meter (TetraCon 325, WTW, Germany), and AT was determined using open-cell titrations conducted with an autoburette titrator (Kimoto, ATT-05, Japan).
Generic Instrument Description	Titrators are instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

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Project Information

Collaborative Research: Ocean Acidification and Coral Reefs: Scale Dependence and Adaptive Capacity (OA coral adaptation)

Website: http://mcr.lternet.edu

Coverage: Moorea, French Polynesia

Extracted from the NSF award abstract:

This project focuses on the most serious threat to marine ecosystems, Ocean Acidification (OA), and addresses the problem in the most diverse and beautiful ecosystem on the planet, coral reefs. The research utilizes Moorea, French Polynesia as a model system, and builds from the NSF investment in the Moorea Coral Reef Long Term Ecological Research Site (LTER) to exploit physical and biological monitoring of coral reefs as a context for a program of studies focused on the ways in which OA will affect corals, calcified algae, and coral reef ecosystems. The project builds on a four-year NSF award with research in five new directions: (1) experiments of year-long duration, (2) studies of coral reefs to 20-m depth, (3) experiments in which carbon dioxide will be administered to plots of coral reef underwater, (4) measurements of the capacity of coral reef organisms to change through evolutionary and induced responses to improve their resistance to OA, and (5) application of emerging theories to couple studies of individual organisms to studies of whole coral reefs. Broader impacts will accrue through a better understanding of the ways in which OA will affect coral reefs that are the poster child for demonstrating climate change effects in the marine environment, and which provide income, food, and coastal protection to millions of people living in coastal areas, including in the United States.

This project focuses on the effects of Ocean Acidification on tropical coral reefs and builds on a program of research results from an existing 4-year award, and closely interfaces with the technical, hardware, and information infrastructure provided through the Moorea Coral Reef (MCR) LTER. The MCR-LTER, provides an unparalleled opportunity to partner with a study of OA effects on a coral reef with a location that arguably is better instrumented and studied in more ecological detail than any other coral reef in the world. Therefore, the results can be both contextualized by a high degree of ecological and physical relevance, and readily integrated into emerging theory seeking to predict the structure and function of coral reefs in warmer and more acidic future oceans. The existing award has involved a program of study in Moorea that has focused mostly on short-term organismic and ecological responses of corals and calcified algae, experiments conducted in mesocosms and flumes, and measurements of reef-scale calcification. This new award involves three new technical advances: for the first time, experiments will be conducted of year-long duration in replicate outdoor flumes; CO2 treatments will be administered to fully intact reef ecosystems in situ using replicated underwater flumes; and replicated common garden cultivation techniques will be used to explore within-species genetic variation in the response to OA conditions. Together, these tools will be used to support research on corals and calcified algae in three thematic areas: (1) tests for long-term (1 year) effects of OA on growth, performance, and fitness, (2) tests for depth-dependent effects of OA on reef communities at 20-m depth where light regimes are attenuated compared to shallow water, and (3) tests for beneficial responses to OA through intrinsic, within-species genetic variability and phenotypic plasticity. Some of the key experiments in these thematic areas will be designed to exploit integral projection models (IPMs) to couple organism with community responses, and to support the use of the metabolic theory of ecology (MTE) to address scale-dependence of OA effects on coral reef organisms and the function of the communities they build.

The following publications and data resulted from this project:

Comeau S, Carpenter RC, Lantz CA, Edmunds PJ. (2016) Parameterization of the response of calcification to temperature and pCO2 in the coral Acropora pulchra and the alga Lithophyllum kotschyanum. Coral Reefs 2016. DOI 10.1007/s00338-016-1425-0.
calcification rates (2014)
calcification rates (2010)

Comeau, S., Carpenter, R.C., Edmunds, P.J. (2016) Effects of pCO2 on photosynthesis and respiration of tropical scleractinian corals and calcified algae. ICES Journal of Marine Science doi:10.1093/icesjms/fsv267.
respiration and photosynthesis I
respiration and photosynthesis II

Evensen, N.R. & Edmunds P. J. (2016) Interactive effects of ocean acidification and neighboring corals on the growth of Pocillopora verrucosa. Marine Biology, 163:148. doi: 10.1007/s00227-016-2921-z
coral growth
seawater chemistry
coral colony interactions

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Program Information

Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Website: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503477

Coverage: global

NSF Climate Research Investment (CRI) activities that were initiated in 2010 are now included under Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES). SEES is a portfolio of activities that highlights NSF's unique role in helping society address the challenge(s) of achieving sustainability. Detailed information about the SEES program is available from NSF (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707).

In recognition of the need for basic research concerning the nature, extent and impact of ocean acidification on oceanic environments in the past, present and future, the goal of the SEES: OA program is to understand (a) the chemistry and physical chemistry of ocean acidification; (b) how ocean acidification interacts with processes at the organismal level; and (c) how the earth system history informs our understanding of the effects of ocean acidification on the present day and future ocean.

Solicitations issued under this program:
NSF 10-530, FY 2010-FY2011
NSF 12-500, FY 2012
NSF 12-600, FY 2013
NSF 13-586, FY 2014
NSF 13-586 was the final solicitation that will be released for this program.

PI Meetings:
1st U.S. Ocean Acidification PI Meeting(March 22-24, 2011, Woods Hole, MA)
2nd U.S. Ocean Acidification PI Meeting(Sept. 18-20, 2013, Washington, DC)
3rd U.S. Ocean Acidification PI Meeting (June 9-11, 2015, Woods Hole, MA – Tentative)

NSF media releases for the Ocean Acidification Program:

Press Release 10-186 NSF Awards Grants to Study Effects of Ocean Acidification

Discovery Blue Mussels "Hang On" Along Rocky Shores: For How Long?

Discovery nsf.gov - National Science Foundation (NSF) Discoveries - Trouble in Paradise: Ocean Acidification This Way Comes - US National Science Foundation (NSF)

Press Release 12-179 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: Finding New Answers Through National Science Foundation Research Grants - US National Science Foundation (NSF)

Press Release 13-102 World Oceans Month Brings Mixed News for Oysters

Press Release 13-108 nsf.gov - National Science Foundation (NSF) News - Natural Underwater Springs Show How Coral Reefs Respond to Ocean Acidification - US National Science Foundation (NSF)

Press Release 13-148 Ocean acidification: Making new discoveries through National Science Foundation research grants

Press Release 13-148 - Video nsf.gov - News - Video - NSF Ocean Sciences Division Director David Conover answers questions about ocean acidification. - US National Science Foundation (NSF)

Press Release 14-010 nsf.gov - National Science Foundation (NSF) News - Palau's coral reefs surprisingly resistant to ocean acidification - US National Science Foundation (NSF)

Press Release 14-116 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: NSF awards $11.4 million in new grants to study effects on marine ecosystems - US National Science Foundation (NSF)

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1415268

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